Technical Memorandum

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Subject: Long Term Water Quality Modeling for Franks Tract Project

Introduction

This technical memorandum summarizes a long term (16 years) modeling and analysis of salinity reduction at key locations in the south Delta for two alternatives of the Franks Tract Project (FTP). The two alternatives considered in this study consist of installation of operable barriers in:

1. Three Mile Slough
2. West False River

The Flooded Island pre-Feasibility Study Report (DWR, June 2005), the interim developments and enhancements of the FTP alternatives and their evaluation (Shrestha, October 2007), and the Value Engineering (VE) study (DWR, May 2007) identified these two alternatives as the preferred alternatives to achieve the objectives of the FTP to reduce salinity in the central and south Delta, and to benefit fish migration. The earlier studies focused on the short term (one to two year) salinity reduction modeling and analyses of the FTP alternatives. The long term results presented in this memorandum are for one operational scheme for the Three Mile Slough alternative and two operational schemes for the West False River alternative.

The Three Mile Slough barrier was operated on a tidal basis: closing the barrier a few hours (usually about 2 to 6 hours) during ebb tides with an objective of balancing net (tidal) flows in the Sacramento River (at Emmaton) and the San-Joaquin River (near Jersey Point). Net (Tidal) flows are residual flows over one tidal cycle (24.75 hour). The Three Mile Slough barrier operation increased the net outward flow in the San Joaquin River (near Jersey Point). This increase in net outward flow helped in reducing sea water intrusion in the central and south Delta. The Three Mile Slough barrier was not operated during the times when 1) there was no sea water intrusion in the central and south Delta; 2) the net outward flow at Emmaton and Jersey Point were balanced; and 3) the combined net outward flow at Emmaton and Jersey Point were small.

The first operational scheme for the West False River alternative involved opening and closing the West False River barrier on a 12 hour cycle, and the second operational scheme involved keeping the barrier closed completely from July through November. Closure of the West False River barrier physically blocks the sea water intrusion to the Franks Tract region, thereby creating a longer path for sea water to reach export facilities in the south Delta (via Old River).

Methodology

Selection of Long Term Hydrology

Table 1 shows the hydrology for the past 100 years (1906 to 2005) for the Delta region. In this period, there were approximately one-third wet years, one-third normal (above and below) years, and one-third dry/critical years. A water year, WY (October to September) is classified as wet, above normal, below normal, dry, or critical depending on the river index (Sacramento Valley or San Joaquin Valley) which is described in Water Rights Decision 1641 (State Water Resources Control Board, 2000). DWR, other agencies and private consultants have frequently used 16 year hydrology (WY 1976 to 1991) to study the long term effects for planning activities. The 16 year hydrology includes: extremes floods (1983, 1986), drought (1987 to1991), and one of the driest years (1977) in the history. In this 16 year hydrology there were 4 wet, 3 normal, and 4 dry, and 5 critical years.

Table 1: Distribution of Water Year Types

Year Type	No. of Years (1906 – 2005)	16 years hydrology (1976-1991)
Wet	34	4 years (1982, 1983, 1984, 1986)
Above Normal	15	2 years (1978, 1980)
Below Normal	17	1 year (1979)
Dry	20	4 years (1981, 1985, 1987, 1989)
Critical	12	5 years (1976,1977,1988,1990,1991)

Selection of Hydrodynamic and Water Quality Model

DWR's Delta Simulation model (DSM2) was used for the long term salinity benefits study. DSM2 is a one dimensional hydrodynamic-water quality model calibrated to the Sacramento-San Joaquin Delta (Nader-Tehrani).

Delta Boundary Conditions

Following boundary conditions were used in the model studies:

- Model Boundary - The boundary of the Sacramento-San Joaquin Delta in DSM2 was specified by the Sacramento River at I Street, the San Joaquin River at Vernalis, and Carquinez Straight at Martinez.
- Downstream Stage - 16 year tides (15 minute intervals) estimated at Martinez (Eli, 2000) were used as downstream stage boundary.
- Delta Inflows and Exports – Delta inflows and exports were obtained from DWR's operational California Simulation Model (CALSIM). The CALSIM simulation was based on Operation Criteria and Planning (OCAP) for a 2001 level of development (LOD).
- Gates: (1) Delta cross channel gate operation was used as specified in the CALSIM run; (2) Clifton Court Forebay gate operation was based on priority-3 operation used

by DWR's Operation and Maintenance Division, and (3) South Delta included temporary agricultural and fish barriers.

- Delta Boundary Salinity – EC at San Joaquin was obtained from CALSIM. EC at Martinez was estimated using the tide at Martinez and the net delta outflows (NDO) (Eli, 2001). Fixed EC values were used at Sacramento River (175 uS/cm), Yolo Bypass (175 uS/cm), East-side streams (150 uS/cm), and Calaveras River (150 uS/cm).

<u>Base Case:</u>
OCAP 2001 hydrology with no project scenario was used for the base case.

<u>Three Mile Slough Alternative</u>
OCAP 2001 hydrology with a barrier installed in Three Mile Slough was used for this alternative. The barrier was operated on a tidal basis to reduce sea water intrusion in central and south Delta by increasing net outward flows in San Joaquin River near Jersey Point when needed.

<u>West False River Alternative</u>
OCAP 2001 hydrology with a barrier installed in West False River was used for this alternative. Two barrier operational scenarios were evaluated in this alternative. The first operational scenario involved opening and closing the barrier on a 12 hour cycle (hereafter denoted by WFR1), and the second operational scenario involved keeping the barrier closed from July through November (hereafter denoted by WFR2). Closure of the West False River barrier physically blocks the sea water intrusion to the Franks Tract region thereby creating a longer path for sea water to reach the export facilities in south Delta (via Old River).

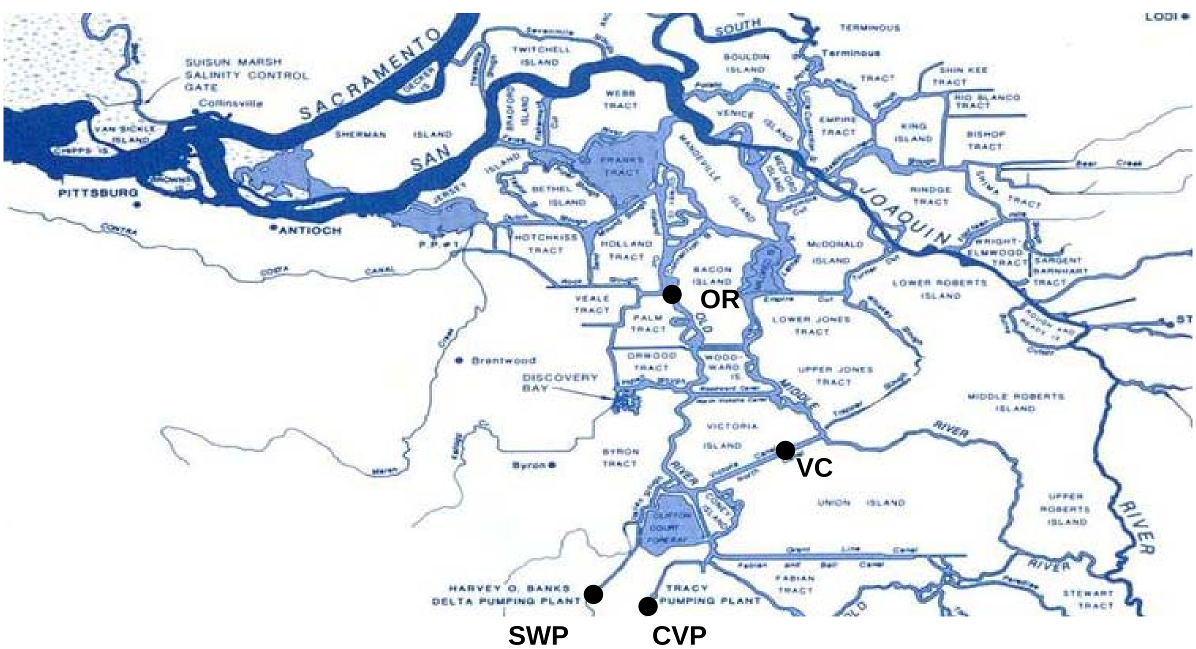

Figure 1 EC Output Locations

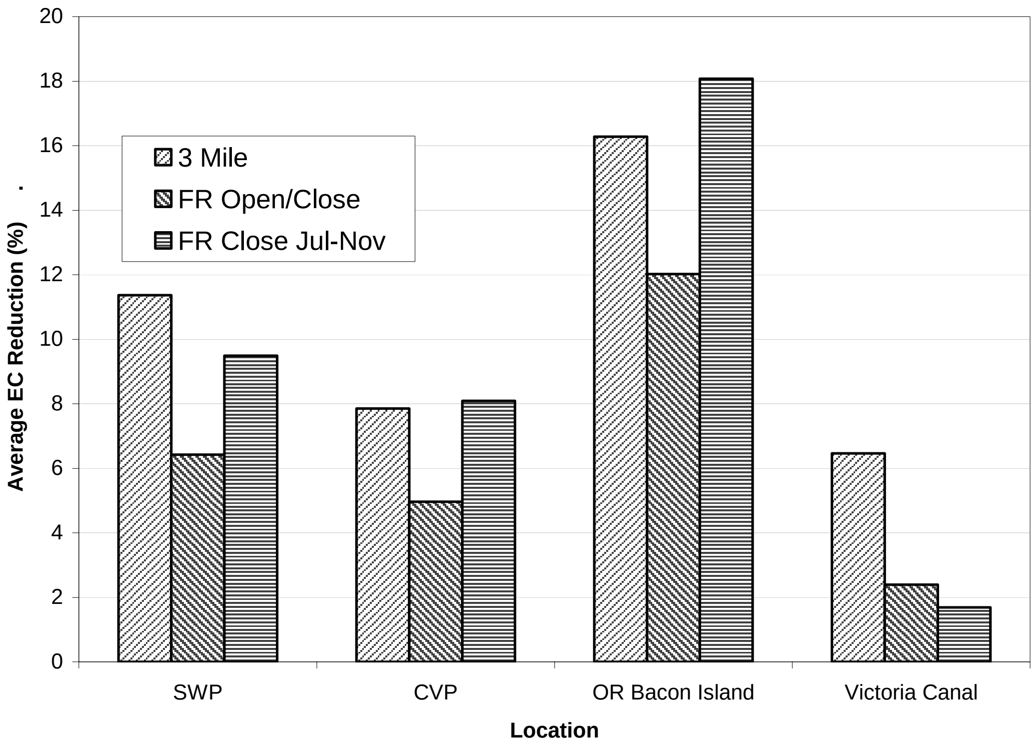

Figure 2. Long Term EC Reduction (Jul – Nov, WY 1976 – 1991)

Modeling Results

Figure 1 shows the four key locations: State Water Project (SWP) Intake, Central Valley Project (CVP) Intake, Old River at Bacon Island, and Victoria Canal, where long term EC results were evaluated and compared. Figure 2 shows the average long term EC reduction (from the base case) for both alternatives at these key locations. The results showed the following:

- The Three Mile Slough alternative provided higher long term salinity reductions at all the four locations than the WFR1 alternative.
- At the CVP intake, the Three Mile Slough alternative and the WFR2 alternative provided about the same amount of salinity reductions.
- At Old River (Bacon Island), the WFR2 alternative provided a slightly higher salinity reduction than the Three Mile Slough alternative.
- The Three Mile Slough alternative salinity reductions were noticeably higher in the Victoria Canal and Middle River (which is not shown here) than the West False River alternative.

The difference in salinity reduction at the Old River and the Middle River/Victoria Canal for the two alternatives is due the principles on which they work. In the West False River alternative, the closure of barrier physically blocks the sea water intrusion into the Franks Tract region, thereby creating a longer path for the sea water to reach Old River. This in turn reduces the salinity at the Old River, and hence, at the SWP and CVP intakes. This alternative, however, does not alter sea water travel length to the Middle River, and Victoria Canal. Therefore, this alternative does not help in salinity reduction in the Middle River/Victoria Canal. In the Three Mile Slough alternative, the closure of barrier (during ebb tide) increases the net outward flows in San Joaquin River near Jersey Point; this increase in net outward flows reduces the salinity intrusion from sea in central and south Delta. This alternative reduces salinity throughout the central and portions of south Delta region. Figure 2 also shows that the all the three operational scenarios provide higher salinity reduction at the SWP than that at the CVP. This is because the CVP gets larger proportion of flow from the San Joaquin River and the SWP contains a higher proportion of sea water.

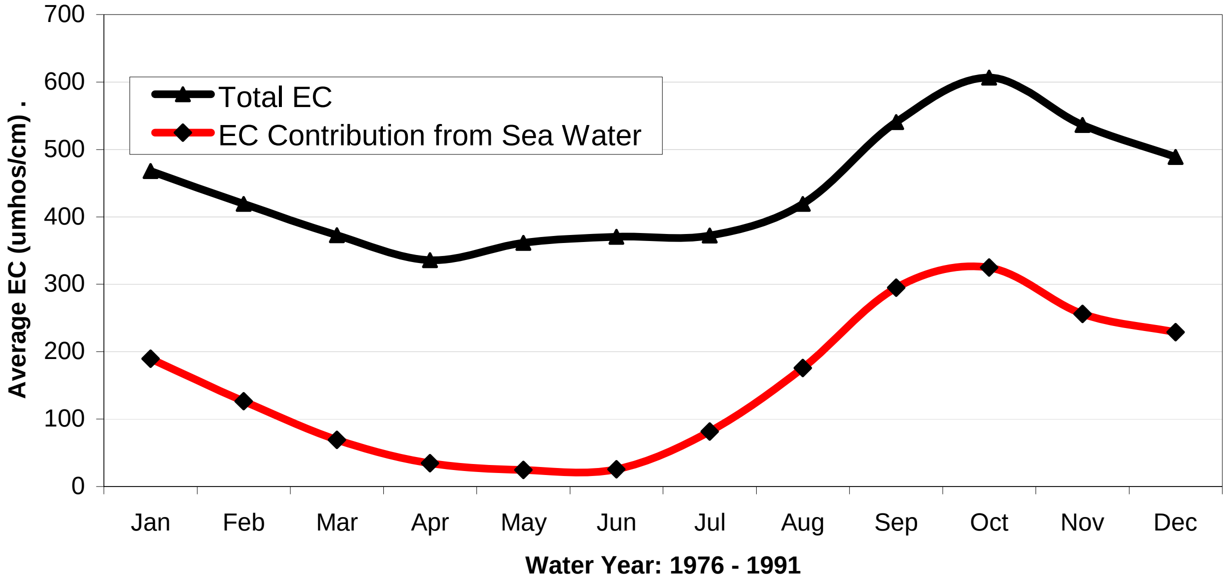

Figure 3. Average Monthly EC at SWP for Base Case (WY 1976 – 1991)

Figure 3 shows the long term monthly average of total EC and the EC contribution from sea water (Martinez) at the SWP. The plot shows that the EC contributions from sea water were higher during July through March. The exports (SWP + CVP) are normally higher during these months compared to the other remaining months (April through June). To benefit juvenile fish migration in the San Joaquin River, the Vernalis Adaptive Management Program (VAMP) requires curtailment of exports and increase in San Joaquin River flows during the April through June period, therefore salinity intrusion is less during this period. Since the FTP reduces salinity contribution from the sea, it does not provide significant salinity reduction during the April through June period. Figure 4 illustrates that the Three Mile Slough alternative outperforms the West False River alternative during sea water intrusion periods.

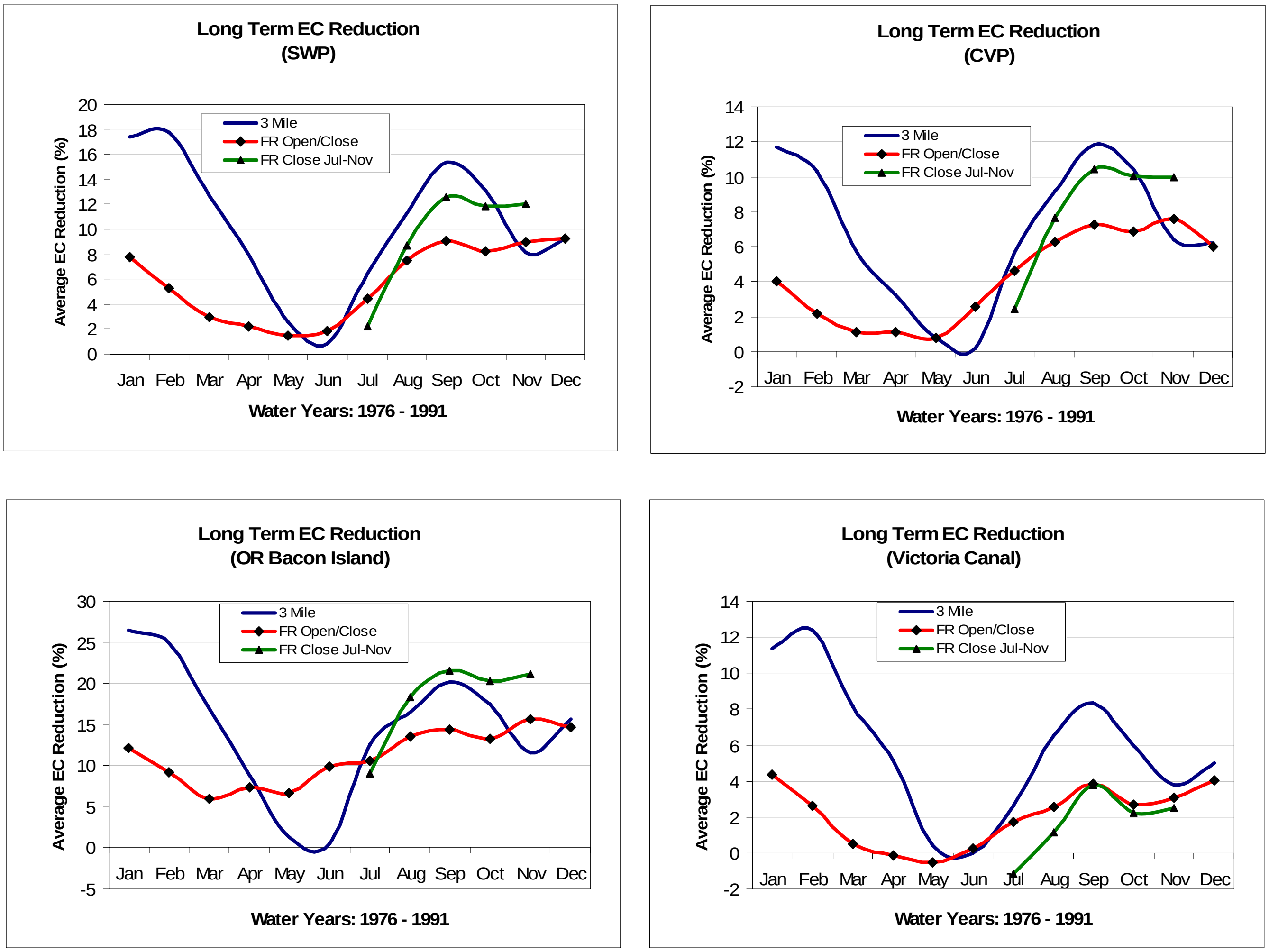

Figure 4. Average Monthly EC Reduction with Franks Tract Project (WY 1976 – 1991)

Figures 5a and 5b show the yearly EC reductions at four key locations for the Three Mile Slough alternative and the WRF1 alternative respectively. Water year 1983 was an extremely wet year and therefore there was no salinity intrusion in central and south Delta. The Three Mile Slough alternative provided higher salinity reductions in WY 1976, 1981, 1985 and 1990 which are classified as dry or critical years. The WRF1 provided higher salinity reductions in critical water years 1977 and 1991.

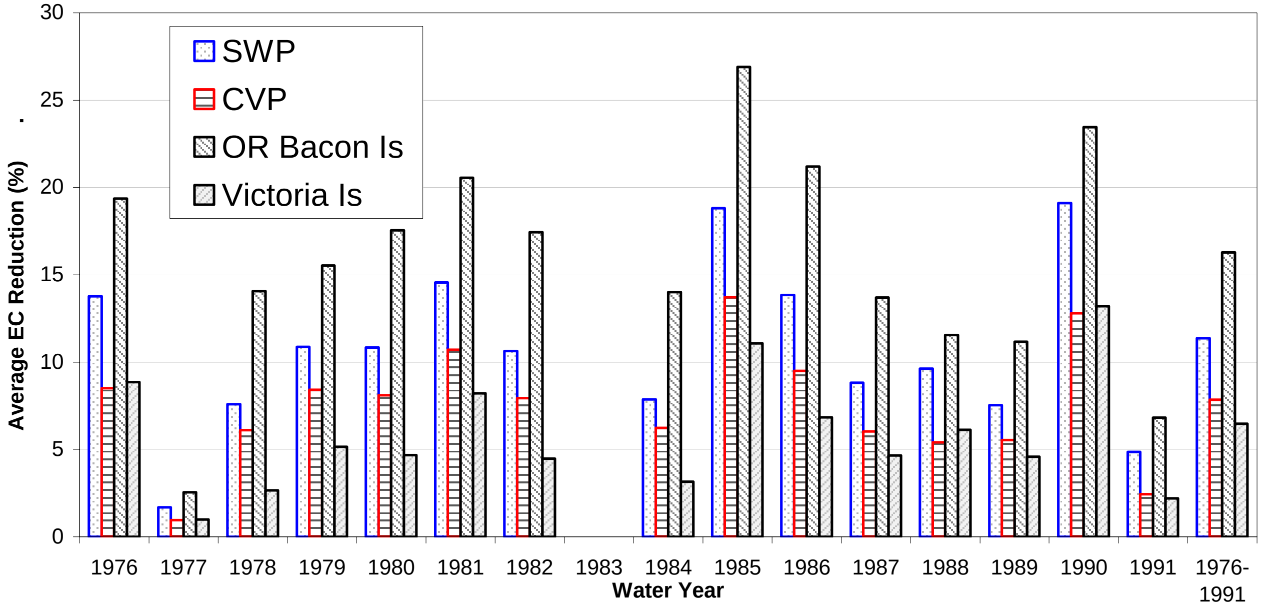

Figure 5a. Average Yearly EC Reduction with Three Mile Slough Alternative (WY 1976 – 1991).

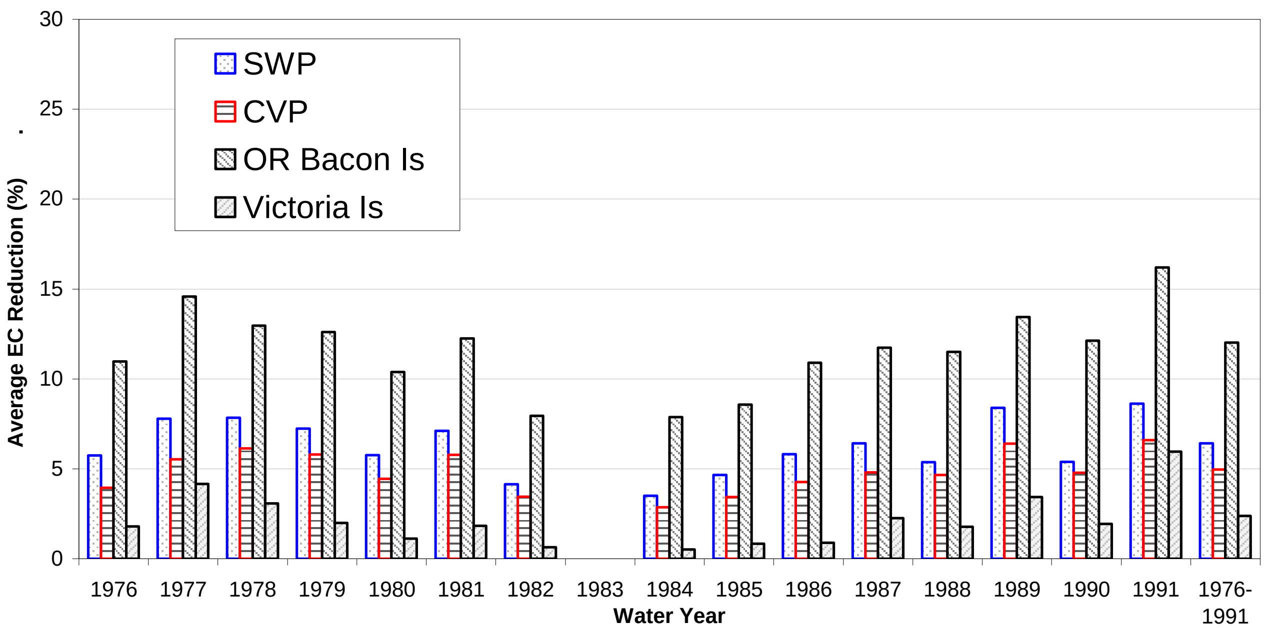

Figure 5b. Average Yearly EC Reduction with West False River (Open/Close Gate Operation) Alternative (WY 1976 – 1991).

Table 2 shows the long term salinity reduction results at the SWP for the Three Mile Slough, WFR1, and WFR2 alternatives by water year type. During the months when the barriers were operated, the Three Mile Slough alternative provided about 10% to 12% EC reduction, the WFR1 provided about 5% to 7% EC reduction, and the WFR2 provided about 4% to 11% reduction in EC at the SWP. In the 16 year period, Three Mile Slough was operated about 55% of the time. The Three Mile Slough barrier was not operated during the times when 1) there were no sea water intrusion in the central and south Delta; 2) the net outward flows at Emmaton and Jersey Point were balanced; and 3) the combined net flows at Emmaton and Jersey Point were small.

Table 2: Long Term Salinity Reduction from Base Case at SWP (WY 1976 – 1991)

		Three Mile Slough Alternative			West False River Alternative					
					WFR1			WFR2		
Water Year Type	No. of Years	Max. Monthly EC Reduction	Average EC Reduction (when operated)	Average EC Reduction (for all months)	Max. Monthly EC Reduction	Average EC Reduction (when operated)	Average EC Reduction (for all months)	Max. Monthly EC Reduction	Average EC Reduction (when operated)	Average EC Reduction (for all months)
Wet	4	20 %	12 %	4 %	9 %	5 %	2 %	14 %	4 %	2 %
Above Normal	2	17 %	10 %	4 %	12 %	7 %	4 %	23 %	11 %	5 %
Below Normal	1	23 %	11 %	6 %	9 %	7 %	4 %	14 %	10 %	5 %
Dry	4	32 %	12 %	10 %	12 %	7 %	5%	22 %	11 %	6%
Critical	5	42%	11 %	8 %	13%	7 %	6 %	24%	11 %	6 %

Conclusions

Following are the conclusions made from the long-term modeling studies:

1. Both the Three Mile Slough alternative and the West False River alternative provide salinity reductions due to sea water intrusion at four key locations.

2. Modeling results indicate that the Three Mile Slough alternative provides higher salinity reductions at the key locations compared to that for the West False River alternative. The Three Mile Slough alternative provides about 10 to 12 percent overall long term average salinity improvement at SWP. The Three Mile Slough alternative provides higher EC reductions during dry, critical and wet years. The WFR1 provides about 5 to 7% EC reduction at the SWP, and the WFR1 alternative provides higher EC reductions during critical years.

3. Closure of the West False River barrier physically blocks the sea water intrusion to the Franks Tract region thereby creating a longer path for sea water to reach the export facilities in south Delta (via Old River). This in turn reduces the salinity at the Old River and the SWP and CVP export facilities. This alternative however does not alter salt path in the Middle River and the Victoria Canal. Therefore the salinity reduction at both the Middle River and the Victoria Canal are minimal.

4. The Three Mile Slough barrier is operated on the tidal basis, closing a few hours during ebb tides. The barrier operations increase the net outward flows in the San Joaquin River (near Jersey Point). This increase in net outward flows helps in reducing the sea water intrusion to the central and south Delta. The Three Mile Slough barrier operation is not required during the times when 1) there is no sea water intrusion in central and south Delta; 2) the net outward flows at Emmaton and

Jersey Point were balanced; and 3) The combined net flows at Emmaton and Jersey Point were small.

5. Closure of the Three Mile Slough barrier during ebb tide increases the net outward flows in San Joaquin River near Jersey Point. This increase in net outward flows reduces the salinity intrusion from the sea in the central and south Delta, effectively reducing salinity throughout the central and portions of south Delta region. Therefore, this alternative provides salinity reductions at both the Middle River and Victoria Canal. This is especially important, as the future intakes for CCWD are proposed in these channels.

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